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# **A LONG TERM EXPERIMENT TO MONITOR LOW FREQUENCY NOISE ACROSS THE EAST COAST OF THE U.S.**

George V. Frisk and G. M. Purdy

Woods Hole Oceanographic Institution  
Woods Hole, MA 02543  
(508)457-2000

## **Long Range Objectives**

To understand the (primarily wind-driven) processes that generate ULF/VLF noise in the ocean and to determine how the noise field varies with time, frequency, and water depth.

## **Project Description**

The ECONOMEX (Environmentally Controlled Oceanfloor NOise Monitoring EXperiment) project involved the deployment of six ONR Ocean Bottom Seismometers (OBS's), equipped with differential pressure gauges and three-component seismometers, and two hydrophone arrays. These sensors were placed along the continental margin of the eastern United States, off Chesapeake Bay, in water depths ranging from 100m to 2500m during the period January to April 1991. Multiple cruises on the R/V OCEANUS carried out the necessary instrument deployments, recoveries and redeployments, and the final instrument recoveries took place during OCEANUS Cruise 238 April 3rd. - April 7th, 1991. One of the key features of ECONOMEX was the availability of concurrent surface gravity wave directional spectra obtained in the SWADE (Surface Wave Dynamics Experiment) project [R. A. Weller et al., Bull Am. Meteor. Soc. 72, 163-183 (1991)]. SWADE provided the necessary environmental controls to permit the interpretation of the data sets in terms of causative processes. ECONOMEX also benefited from the availability of deep seismic profiles determined by the EDGE survey [R. E. Sheridan et al., Am. Geophys Union 72, EOS, Transactions, Spring Meeting 273-274 (1991)]. These data enabled the inclusion of realistic geoacoustic parameters in our predictive models.

Specific objectives of ECONOMEX were to determine the primary mechanisms for noise generation in the band 0.02-2 Hz, to study the downslope propagation of wind-induced noise on continental margins, to use the inevitable East Coast winter storms as "controlled" sources to test models of noise generation and propagation, and to assess the relative contributions to the local noise field of energy that has propagated from distant sources.

## **Accomplishments and Primary Conclusions**

- The data clearly show both single and double frequency microseisms. The former are due to linearly generated pressure fluctuations following a single surface wavetrain, while the latter result from nonlinear interaction between opposing wavetrains.

- Single-frequency microseisms are strongest at the shallowest sensor (100m). Levels as high as 160 dB re 1 ( $\mu\text{Pa}/\text{Hz}$ )<sup>2</sup> were measured, and there appears to be significant generation of higher order harmonics by finite amplitude effects. The intensity and peak frequency of the single-frequency microseisms decreases rapidly with depth, as expected. Single-frequency microseisms exhibit little temporal variability relative to the surface wave spectra.

- Double-frequency microseisms are observed at all depths and show little depth dependence. However, unlike the single-frequency microseisms, their temporal variations closely follow the surface of wave spectra. Because the peak frequency of the single-frequency microseisms diminishes with depth, whereas the peak of the double-frequency microseisms is relatively constant, a spectral gap whose width increases with depth is observed.

Most of the features described above are predicted by a theoretical model developed in our group. The model applies to horizontally stratified ocean environments having arbitrary compressional and shear wave speed profiles in the seabed. It is an extension of Cato's treatment for an infinitely deep, homogeneous ocean [J. Acoust. Soc. Am. **89**, 1076-1095 (1991)], based on the realization that Cato's coupling factors are proportional to the depth-dependent Green's function for the stratified environment. Contributions from both virtual monopoles (single-frequency microseism) and virtual dipoles of the vertical and horizontal orientations (double frequency microseisms) are included in the theory. Consistent with the observations, the theoretical computations show that the monopoles usually dominate in the band 0.01-0.1 Hz, whereas the dipoles dominate in the band 0.1-1 Hz. Some of the discrepancies between the data and predictions may be attributable to lateral inhomogeneities in the environment, particularly since the experiment was performed in a continental shelf/slope system. More sophisticated modeling efforts should also account for lateral inhomogeneities in the source mechanism (i.e. the surface gravity wave field).

#### **Publications and Abstracts:**

T. E. Lindstrom, "Predictions and Observations of Seafloor Infrasonic Noise Generated by Sea Surface Orbital Motion," unpublished Ocean Engineer thesis, MIT/WHOI Joint Program in Oceanographic Engineering, 1991.

D. K. Wilson and G. V. Frisk, "Analysis and Modeling of the Results of ECONOMEX," J. Acoust. Soc. Am., 93, 2417 (1993).

T. E. Lindstrom and G. V. Frisk, "Predictions and Observations of Seafloor Infrasonic Noise Generated by Sea Surface Orbital Motion," submitted to J. Acoust. Soc. Am.

#### **Publications to be submitted:**

D. K. Wilson and G. V. Frisk, "Prediction of Noise Generated by Surface-Wave Orbital Motion in Stratified Ocean Environments," to be submitted to J. Acoust. Soc. Am.

D. K. Wilson, G. V. Frisk and C. J. Sellers, "Measurements of Ultra-Low Frequency Noise off the Eastern U.S. Coast", to be submitted to J. Acoust. Soc. Am.

G. V. Frisk, D. K. Wilson and T. E. Lindstrom, "Generation of Microseisms by Sea Surface Wave Motion," to be submitted to Nature.

D. K. Wilson, C. J. Sellers, T. E. Lindstrom and G. V. Frisk, "ECONOMEX: Data analysis Report," to be published as a WHOI Technical Report.